1873MNRAS..33..279P

The Transit of Venus in 1874. By Richard A. Proctor, B.A., Cambridge.

It will be in the remembrance of most of the Fellows of this Society that four years ago a paper of mine was read in which the circumstances of the transit of 1874 were subjected to a more careful and detailed examination than had till then (to the best of my knowledge) been applied to the subject. Towards the end of that paper* I pointed to certain conclusions respecting the application of Halley's method during the transit, which were certainly new at that time, though they have since been abundantly confirmed in many different quarters, notably in the pages of the *Nautical Almanac* for 1874. Two months later, or in May 1869, I read a paper in which these conclusions were further advocated, and illustrated by a series of projections.† Thereafter, with the exception of two or three short notes to meet objections which had been raised by Mr. Stone to points of detail, I have not, at any of our meetings, or in Council, touched further upon the subject of the approaching transits.‡

I trust it will not be thought by the Society that I have exhibited any undue impatience. My fear is, indeed, that hereafter the examination of all the circumstances may lead to the impression that I have been remiss (holding the opinions which I entertain on this subject) in leaving the matter to so late an epoch. This, however, will be regarded, I conceive, as a fault on the right side, more particularly when I mention that, as editor of the Proceedings (during Professor Cayley's Presidentship) I have

* I feel bound to dwell upon the fact that the paper was commenced, and continued (*pari passu* with the calculations whose results it presents) up to the portion referred to in the title as "An Addendum," before I had any notion that the results at which I should arrive would be different from those indicated from the year 1857 to December 1868, by the Astronomer Royal. Any one who will examine the essay carefully will recognise abundant evidence of this fact. It was somewhat hastily and quite mistakenly assumed that the paper was "an attack from beginning to end" on the Astronomer Royal's essays.

† In this paper, the series of results which I controverted are simply described as those obtained by a certain process, and they are tabulated under the letter A.; Puiseux's results, which are much more near to exactness, are tabulated under the letter B.; my own under the letter C.

‡ Certain recent events compel me to add two facts relating to the history of this matter :—

Last midsummer I wrote to the Astronomer Royal urging (strongly, but courteously) the points which seemed to me (and still seem) most important. I waited half a year. Then I wrote again, describing what I proposed to do in the present paper and illustrative chart. The construction of this chart did not occur to me *after* the meeting of the Council in January last, as it has pleased some to state. On the contrary, the chart (completely ready for the engraver) was submitted to inspection at that very meeting, as the minutes will show; and its publication in our Proceedings was authorised by a unanimous vote of the members of Council then present.

Downloaded from http://mnras.oxfordjournals.org/ at Florida Atlantic University on August 7, 2015

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1873MNRAS..33..279P

felt some degree of delicacy in touching upon a matter which had formerly been a subject of discussion between myself and the late First Assistant at the Greenwich Observatory.

There is now no time for further delay, at least as respects the part of the subject which I propose chiefly to consider — the advisability, namely, of endeavouring to secure Government assistance for an expedition to the Antarctic regions with the object of applying Halley's method to the transit of December 9, 1874.

Moreover, it is absolutely necessary for the due enforcement of my views (now that time so presses) that I should indicate precisely how and where the mistakes arose which led to the adoption of views altogether different. Because if I fail to do this, the result will inevitably be that many persons will suppose me to be merely advocating a certain opinion (and that against the leading authority in all such matters), whereas in reality the question is one of easily ascertainable facts. In saying this I speak from experience. Four years ago, I published my views in our *Monthly Notices*, without explaining where and how the views which I opposed had had their origin ; and I find that quite a large proportion of those who read my papers judged that I merely differed from Sir George Airy on a matter of opinion, not on matters of fact (mathematically testable).

What I propose to prove, in what follows, is, that certain advantageous circumstances, which had been supposed to exist only in the case of the transit of 1882, exist in a greater degree in the case of the earlier transit ; that difficulties which render the observations of Halley's method inapplicable in 1882 do not exist in 1874 ; and, lastly, that the statements (I may say the earnest appeals) made by the Astronomer Royal in the case of the transit of 1882, pledge this country (because made by its official astronomical representative) to the duty of undertaking an expedition to view the transit of 1874 (now that its circumstances are known) from some Antarctic station or stations.

Let it be premised that the reasoning by which, in 1857, it seemed to be demonstrated that Halley's method is inapplicable in 1874, is sound in its general bearing. It breaks down only when tested by details.

Let Fig. 1 represent the face of the Earth as supposed to be seen from the Sun during a December transit, such as either of the transits now approaching. Now the Earth during the transit is moving from right to left, or in the direction shown by the long arrow. Her rotation shifts points on her surface in the way shown by the small arrows on the latitude parallels, the shift due to this cause being greatest on the equator. This motion manifestly takes place in a sense adverse to that of the Earth's motion of revolution, everywhere except at stations on the shaded lune of the disk. Now *Venus* transits with the excess of her motion of revolution over the Earth's ; and anything which tends

Downloaded from http://mnras.oxfordjournals.org/ at Florida Atlantic University on August 7, 2015

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1873MNRAS..33..279P

to reduce the effects of the Earth's motion of revolution, increases the excess of *Venus's* motion,—or, in other words, hastens *Venus* in her transit. So that at every point of the unshaded portion of the disk in Fig. 1 *Venus* is hastened, more or less, by the effects

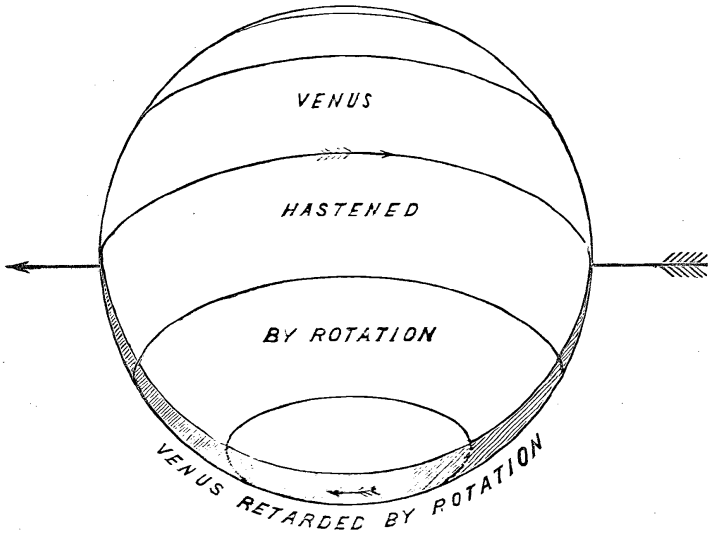


Fig. 1.

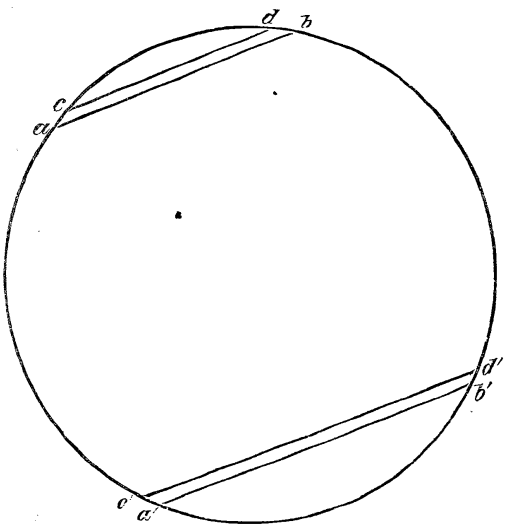


Fig. 2.

due to the Earth's rotation. On the contrary, at every point on the shaded portion of the disk *Venus* is retarded in her transit.

Now let it be noticed that these circumstances affect diversely

Downloaded from http://mnras.oxfordjournals.org/ at Florida Atlantic University on August 7, 2015

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1873MNRAS..33..279P

the two transits of such a pair as we are now awaiting. If fig. 2 represents the Sun's disk, the north point being uppermost, then the lines $a\,b$, $c\,d$, will represent chords of transit in 1874 ($a\,b$ being the chord for a northern, $c\,d$ being the chord for a southern observer); and $a'\,b'$, $c'\,d'$ will represent chords of transit in 1882 ($a'\,b'$ being the chord for a northern, $c'\,d'$ the chord for a southern station).

Now it is manifest that in 1874 the conditions affecting the duration of the transit as seen at a northern station are adverse. The chord $a\,b$ is longer, owing to the northerly latitude of the observer; but *Venus* is hastened on her course, and therefore the lengthening is not so great as it otherwise would be. We have then one favourable and one unfavourable condition, the latter to some degree cancelling the former. (In some transits of the kind, the effect of rotation wholly cancels, or even more than cancels, the effect due to latitude.) The southern station, if taken where, throughout the transit, the observer is on the portion of the disk represented without shading in Fig. 1, will give conspiring effects. The chord of transit $c\,d$ will be shortened, and *Venus* will be hastened on her course. Hence we have for this station two favourable conditions. In all we have three favourable conditions and one unfavourable condition,—so that if the conditions are all equal in value we have a balance of only *two* favourable conditions.

On the other hand, in such a transit as that of 1882 we can theoretically secure four favourable conditions. We have at the northern station the shortened transit-chord $a'\,b'$, and a hastening of *Venus*, or two conspiring conditions. At a southern station we have the lengthened transit-chord $c'\,d'$, and by taking a station which throughout the transit lies on the shaded part of the disk (that is, an Antarctic station passing below the pole during the transit hours), we have *Venus* retarded on her transit-path, or again we have two conspiring conditions. In all then we have *four* favourable conditions, or twice as many as we obtain for the balance of favourable conditions in 1874.

This is theoretically sound. Moreover, it is quite commonly the case that the effects due to rotation are equivalent to those due to latitude, and that therefore the adverse conditions at a station placed as the northern station in 1874, may be regarded as cancelling each other. In the celebrated transit of 1769, for example, the conspiring effects of rotation and latitude were nearly equal. The Astronomer Royal, in his *Popular Astronomy* (published in 1848, be it noticed), justly assigns to rotation 10 minutes out of the observed maximum difference of duration, 22 minutes. It does not seem rash to infer that he had this result in his thoughts (misleading him, in fact) when, after mentioning that the northern stations best placed as respects latitude would probably not be occupied in 1874, he proceeded to remark in 1857 that

Downloaded from http://mnras.oxfordjournals.org/ at Florida Atlantic University on August 7, 2015

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1873MNRAS..33..279P

the "observable difference" in the earlier transit would "probably not be half of that in 1882" * It is at any rate noteworthy that the investigation then made into the conditions of the transit of 1874 did not claim to be accurate on points of detail,—in fact, the estimated epochs for the beginning and end of the transit were each of them in error by nearly a full hour. So that we may regard the opinion just quoted as based on the general considerations previously indicated, not on any exact investigations of the circumstances of the transit of 1874 in points of detail. The use of the word "probably," in fact, suffices to show this.

But, be this as it may, it is unquestionably the case that those were the last words of the Astronomer Royal on the point in question,—"the observable difference of duration" in 1874 "will probably not be half of that in 1882." When he spoke again about the general subject in 1864, and again in 1865, he confined his remarks altogether to the transit of 1882. In December, 1868, he remarked that Halley's method had been shown to "fail totally" in 1874.

Now let us inquire how far this statement is justified by facts, when details come to be considered.

Let it be noticed that at the northern station the effect of rotation was supposed to cancel, or nearly so, the effect due to difference of latitude. In other words, at the best northern station there would be scarcely any lengthening of the durations. This is a very simple issue, relating to a question of fact, not of opinion. Now in May, 1869 (see our *Monthly Notices* for that month, page 315), I stated that at Nertchinsk, in Siberia, the transit would be lengthened by $15\frac{1}{2}$ minutes. How considerable this lengthening is will be seen at once, when I point out that by imagining the Earth's rotation reversed, so as to conspire with the effect of latitude, we could only obtain as an absolute maximum of difference (with the Sun suitably high both at ingress and egress) the value 21 minutes, so that we may regard $17\frac{3}{4}^{m}$ as the difference due to latitude alone, and capable of being only affected $2\frac{1}{4}^{m}$ either way by rotation; and it never happens in any transit that the absolute maximum of difference is obtainable. But now as to the accuracy of my statement:—Referring to the *Nautical Almanac* for 1874, I find the following statements respecting the mean duration of the transit (for internal contacts) and the duration at Nertchinsk Mines. At p. 434,—

	h	m	s	
Internal Contact at Ingress	14	15	24	G.M.T.
,, Egress	17	57	26	
Consequently the duration of the Transit as seen from the Earth's centre is ..	3	42	2	

* See the *Monthly Notices* for May, 1857, p. 215.

Downloaded from http://mnras.oxfordjournals.org/ at Florida Atlantic University on August 7, 2015

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1873MNRAS..33..279P

At p. 20 of the Appendix,—

Nertchinsk Mines.

Lat.	51° 18′ N.	Int. Contact at Ingress,	Dec.	8	h 22	m 8·2	Local T.
Long.	119 36 E.	,, Egress,	,,	9	2	5·3	
Consequently the Duration of the Transit as seen at Nertchinsk Mines is					3	57·1	

Or the lengthening at this station is $3^h\ 57^m{\cdot}1 - 3^h\ 42^m\ 2^s = 15^m\ 4^s$.

Now if it be noticed that the place dealt with in the *Nautical Almanac* lies 42′ of latitude south of Nertchinsk itself (at least according to the position given in Phillips's Atlas, Index, p. 22,) and that this difference corresponds to about 25 seconds of time in the duration* (which is, of course, reduced the further south the station is taken) it will be manifest how closely my graphic construction corresponds with the results of the calculations employed in obtaining the corresponding values in the *Nautical Almanac*.

And if further confirmation be required let it be noticed that Russia has in a very practical way adopted the conclusion which I believe I was the first to point out, by selecting Nertchinsk Mines as a station for observing the transit. This station is by no means good for applying Delisle's method; it is inferior to many Russian stations (even) as respects the accelerated ingress, and to Orsk, Omsk, Tobolsk, Perm, Astrakhan, Odessa, and many other stations as respects the retarded egress. It is, moreover, a situation which nothing but an amazing zeal in the cause of science could induce any astronomer to select as an observing station in December,—since it lies close to the northern pole of winter cold (it lies, in fact, on the isocheimenal of 13° F. below zero). But because it is the very best northern station for applying Halley's method, Russia has nobly undertaken to occupy it.† This circumstance, apart from the confirmation it affords to the statements which I published four years ago, is one which ought to influence this country strongly, if it should be demonstrated (as I hope to demonstrate a page or two further on), that there are corresponding southern stations, which this country could occupy, if not less zealous than Russia in the cause of science.

But doubts may still remain whether in stating that "the observable difference in 1874 will probably not be half of that in 1882;" the Astronomer Royal had the difficulty of finding a

* This will clearly be seen by marking in a point 42′ south of Nertchinsk in maps 5 and 6 illustrating my paper in the May number of the *Monthly Notices* for 1869.

† This I infer from the fact that it is included by Mr. Hind among the selected stations, with which alone he undertakes to deal in the Appendix to the *Nautical Almanac* for 1874.

Downloaded from http://mnras.oxfordjournals.org/ at Florida Atlantic University on August 7, 2015

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1873MNRAS..33..279R

northern station alone in view. Let us, therefore, inquire what is the observable difference, not as between the best northern station and the mean duration, but as between the best northern station and some accessible southern station.

Here, adopting the opinion strongly expressed by the Astronomer Royal (as I shall presently show) that an Antarctic station ought to be occupied if suitable time-differences can thus be secured, we have a very wide choice of places suitable for reconnaissance. But selecting only a station which is known to be accessible, and has been advocated by eminent naval men and geographers (see the *Monthly Notices* for December 1868, and compare the opinions of Captain Richards, Admiral Ommanney, and Commander Davis), namely, Possession Island, near South Victoria Land, let us compare the difference between the durations at this station and Nertchinsk with the maximum observable difference to be obtained in 1882. Still further to favour the transit of 1882, let us in its case take as the Antarctic station Sabrina Land, though the naval authorities above referred to could find nothing to say in its favour. At this latter station, as compared with the best northern stations in North America, there is, according to the Astronomer Royal's correct estimate, a difference of 28^m very nearly. Now at Possession Island the transit of 1874 will be shortened 6^m at the beginning, and $11^m{\cdot}4$ at the end, or $17^m{\cdot}4$ in all. Adding this interval to the lengthening by $15^m{\cdot}1$ at Nertchinsk Mines, we obtain a difference of $32^m{\cdot}5$, that is a *greater* observable difference than in 1882 in the proportion of more than 7 to 6.

But this is far from being all. As a matter of fact, not only is Sabrina Land useless in 1882, because the Sun's elevation at ingress will be only about 4°; but Possession Island (where the difference of elevation will be reduced to 24^m) is also useless, because the Sun's elevation will be only 5° at ingress; and there is no other station where Halley's method can be applied at all advantageously in 1882.

Now in 1874 none of these difficulties present themselves. At Possession Island, which would render available the excellent time-difference of $32\frac{1}{2}$ minutes, the Sun will be 38° high at ingress and 20° high at egress. At Sabrina Land, if this station could be made available, there will be the same time-difference, and solar elevations of 45° and 43° at ingress and egress respectively. At Adelie Land the same time-difference, and the respective solar elevations of 45° and 34°. And lastly, as respects Antarctic stations, at Enderby Land there will be the yet greater time-difference $35\frac{1}{2}$ minutes, and solar elevations 20° and 39° respectively at ingress and egress.

And next, I would invite special attention to the distinct, I may even say the emphatic manner, in which the Astronomer Royal, speaking as the representative of British astronomy, has marked his sense of the duty of this country in the matter of the coming transits. In what I am about to quote he is speaking

Downloaded from http://mnras.oxfordjournals.org/ at Florida Atlantic University on August 7, 2015

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1873MNRAS..33..279P

throughout of the transit of 1882, but the application of his remarks to the earlier transit (now that the superior advantages of Antarctic stations in 1874 has been demonstrated) cannot fail to be generally recognised.

In 1857, the Astronomer Royal's remarks were thus reported (*Monthly Notices* for May 1857, p. 216): "The southern tract is a part of the Antarctic land discovered by Lieut. Wilkes, of the United States Navy,* included between Sabrina Land and Repulse Bay. The Astronomer Royal is informed by General Sabine that the 6th of December is rather early in the season for a visit to this land, but probably not too early, more especially as firm ice will be quite as good for these observations as dry land. . . . It would be extremely desirable that the country should be reconnoitred some years before the transit." (The whole passage should be studied, but space will not permit me to quote any considerable portion of the passages I refer to here.) Again, in the same Report (p. 221): "The Astronomer Royal argues that the future astronomical public will not be satisfied unless all practical use" (probably a misreport for "practicable use") "is made of the transits of *Venus* in 1874 and 1882, and that for these the determination of some distant longitudes, and a reconnaissance of Wilkes' Land, must be effected within a few years."

The next remarks of the Astronomer Royal on this subject appeared in the *Monthly Notices* for June 1864, pp. 173–177. In this paper, after considering the circumstances of the transit of 1882 (leaving that of 1874 unmentioned), he proceeds to say: "On the whole, I think it very desirable that a reconnaissance should be made of the points under consideration, and that it should not be long deferred. The first locality to be examined is that in 7^h east longitude, between Sabrina Land and Repulse Bay; and the points to be ascertained are, (1) whether the coast is accessible in December 6; (2), whether a latitude of 65° can be reached; (3), whether the Sun can be observed" (under certain conditions which affect the problem unfavourably in 1882, but have no existence in 1874). "Should the answer to the first or third questions be negative, then it would be proper to examine other portions of the south continent, say in longitude not very different from 4^h west, but with no particular restriction except that of gaining the highest possible south latitude."

The next reference to the subject appeared in the *Monthly Notices* for May 1865, pp. 201-203, and the Astronomer Royal's remarks on this occasion are so excellent in themselves, so thoroughly *apropos* of the present geographical position, and apply so forcibly to the circumstances now known to exist in the case of the transit of 1874, that I venture to quote them nearly in full. The paper bears the title, "Letter from the Astronomer

* This Antarctic "land" had however, been sailed over by Ross in 1846–7; and in the later discussion of the subject Sabrina Land was substituted for Wilkes' supposed continent.

Downloaded from http://mnras.oxfordjournals.org/ at Florida Atlantic University on August 7, 2015

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1873MNRAS..33..279R

Royal to Sir R. I. Murchison, K.C.B., President of the Royal Geographical Society." It runs thus:—

"I have learned, through the public papers, the tenor of late discussions at the Royal Geographical Society in reference to a proposal for an expedition towards the North Pole. I gather from these that the object proposed, as bearing on science, is not so much specific as general; that there is no single point of very great importance to be obtained, but a number of co-ordinate objects whose aggregate would be valuable. And I conclude that the field is still open for another proposal, which would give opportunity for the determination of various results, corresponding in kind and in importance to those of the proposed Northern Expedition, though in a different locality, and would also give information on a point of great importance to Astronomy, which must be sought within a few years, and which it is desirable to obtain as early as possible.

"In the year 1882, on the 6th of December, a transit of *Venus* over the Sun's disk will occur; the most favourable of all phenomena for solution of the noble problem of determining the Sun's distance from the Earth, provided that proper stations for the observation can be found. (It will be remembered that it was for the same purpose that the most celebrated of all the British scientific expeditions, namely, that of Captain Cook to Otaheite in 1769, was undertaken; the British part of the enterprise was perfectly successful; but there have always been doubts of the accuracy of the corresponding observations in Lapland, which render a repetition of the observation very desirable.) In the *Monthly Notices of the Royal Astronomical Society* for 1864, June 10, I have very carefully discussed the circumstances of the coming transit, in reference to the selection of observation-stations. For the Northern stations there will be no difficulty; they will be on the Atlantic seaboard of North America, or at Bermuda; all very favourable and very accessible. For the Southern stations the selection is not so easy; the observation must be made on the Antarctic Continent; if proper localities can be found there, and if the circumstances of weather, &c. are favourable, the determination will be excellent; if those favourable circumstances do not hold, no use whatever can be made of the transit."

Then follow certain sentences from the cited *Monthly Notices*, sentences bearing on the selection of Southern stations, and including the passages which I have quoted above. The Astronomer Royal proceeds as follows:—

"The astronomical object of a Southern Expedition is, I trust, sufficiently explained in the sentences which I have quoted. In the event of such an expedition being undertaken, the precise determinations which I have indicated as bearing on the astronomical question must (from the nature of the case) take precedence of all others. But there would be no difficulty in combining with them any other inquiries, of geography, geology, hydrography,

Downloaded from http://mnras.oxfordjournals.org/ at Florida Atlantic University on August 7, 2015

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1873MNRAS..33..279P

magnetism, meteorology, natural history, or any other subject for which the localities are suitable.

"And I have now to request that you will have the kindness to communicate these remarks to the Royal Geographical Society, and to take the sense of the Society on the question, whether it is not desirable, if other scientific bodies should co-operate, that a representation be made by the Royal Geographical Society to Her Majesty's Government on the advantage of making such a reconnaissance of the Southern Continent as I have proposed; primarily in the interest of Astronomy (referring to my official responsibility for the importance of the examination at this special time); but conjointly with that, in the interests, perhaps ultimately more important, of geography and other sciences usually promoted by the Royal Geographical Society."

I need scarcely remind my readers of the paper read before the Society by the Astronomer Royal in December 1868. Nevertheless, it is necessary, first, to point out that at that late epoch the error respecting the transit of 1874 still remained uncorrected, and that the Astronomer Royal then (see p. 33 of the *Monthly Notices* for December 1868) repeated that "the method by observation of the interval in time between ingress and egress at each of the stations at least, on nearly opposite parts of the earth, fails totally for the transit of 1874." At that time also, notwithstanding the relatively unfavourable circumstances for applying this method (Halley's) to the transit of 1882, and the very favourable conditions under which Delisle's method can be applied in 1882, he urged that only three stations should be occupied for Delisle's method in that year, the instruments of the five 1874 Expeditions, "thus set free from two stations," being required at an observing station on the Southern Continent. He had now so far changed his mind as to the method of dealing with Antarctic difficulties, as to speak in the following terms:— "The choice of station being made," he said, "I would not recommend any reconnaissance, but I would propose that an expedition should go direct to the selected point in good time for the observation of the phenomenon. The season is early for South Polar expeditions, and any difficulties produced by ice would probably diminish every day. A station being gained, all that is necessary in the way of subsidiary observation is, a few days' observation to give clock-rate, then the clock times of the two phenomena will furnish all that is required. The first action to be undertaken by the Government," he proceeds (and I invite special attention to the point), "is to procure the stock of instruments, and this ought to be done without delay. An observing plant like that," (described in the earlier part of the same paper), "is not to be obtained in haste, and the proposed expedition might be entirely crippled by a small negligence on this point. The equipment of ships and the selection of officers would probably require much less time."

It will be noticed that if such a plan as this could be followed

Downloaded from http://mnras.oxfordjournals.org/ at Florida Atlantic University on August 7, 2015

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1873MNRAS..33..279P

out in 1874, the necessity of wintering in Possession Island would be avoided. However, it appeared to the naval authorities who followed the Astronomer Royal in addressing the meeting, that the more certain course for achieving the desired result would consist in the preparation of an expedition to winter in Possession Island. I quote the following passages as bearing specially on the feasibility of such an expedition :—

Admiral (then Captain) Richards, Hydrographer to the Admiralty, said, "My own opinion, looking to the uncertainty of finding a wintering station for a ship, is that landing a party on Possession Island," or one of the islands farther south, "would be the most feasible course, and there would be little doubt of the facility of reaching one or other of these islands with a suitable steam-vessel, making Tasmania or New Zealand the base of operations. Doubtless a year passed in this region would be most profitably employed in adding to our knowledge of magnetism, and various other branches of physical science."

Admiral Ommanney said, *inter alia*, "I fully concur in all that has fallen from the Hydrographer to the Navy, and hope ere long to hear that operations are making for sending out to explore the Antarctic Seas."

Commander J. A. Davis, who had accompanied Sir James Ross in that most gallant expedition during which Victoria Land was discovered, and who had himself landed at Possession Island, said that "he believed there would be no difficulty whatever in again effecting a landing in the same place." "With regard to the period of the season at which the transit took place, it was to be remembered that the 6th of December was so early that no ships had ever reached the Antarctic Circle by that date; and as it would be necessary to arrange the instruments, &c. preparatory to the observation, he might say that the ships ought to be on the spot at least a month before. This would be the 6th of November, a date altogether out of the question; and as the ships could not winter in the South, the party would necessarily have to land the year before; but with good tents he had no doubt they could pass the winter very comfortably" (this, of course, and what follows, will not be taken strictly *au pied de la lettre*); "they would have a pleasant prospect before them, and plenty of penguins to live on. In comparison with Kerguelen Island and the Crozets," he proceeded, "the chances of observing the transit—meteorologically speaking—would be greatly in favour of South Victoria."

Captain Toynbee also expressed an opinion strongly adverse to the meteorological chances at Prince Edward's Islands, the Crozet's, and Kerguelen Land, since their neighbourhood is, he said, "so far as my experience goes, subject to a great deal of thick weather."

It remains only to mention that the chart which illustrates this paper, besides being useful in showing the path of *Venus*' centre across the Sun's disk, as seen from the stations named, and

Downloaded from http://mnras.oxfordjournals.org/ at Florida Atlantic University on August 7, 2015

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1873MNRAS..33..279R

indicating the corresponding path for any station whatever, affords an independent proof of that which, however, has already been abundantly demonstrated—the fact, namely, that Halley's method is most advantageously applicable in 1874. The chart requires little explanation. The simplest geometrical considerations will show that, imagining a long line to extend through *Venus*' centre at any moment during transit to the Earth on one side, and the Sun on the other; then if the end towards the Earth be supposed to be carried swiftly along the outlines of the terrestrial continents, and over the meridians and parallels, the end towards the Sun would trace out such projections as are shown in the chart. Moreover, it is manifest that from whatever point on the Earth such a line extends, the point in which the line meets the Sun is that on which *Venus*' centre is at the instant projected. Accordingly, we have only to determine the aspect of the Earth's disk as seen from the Sun at any instant, and the position of *Venus*' centre, on the Sun's disk as seen from the Earth's centre at that instant, to have at once the means, by constructing such an inverted projection as is seen in the successive pictures of the chart, of determining the apparent position of *Venus*' centre as seen at that instant from any point of the Earth's sunlit hemisphere.

The chart itself shows clearly the relation between the strip of the Sun's disk (divided into three portions in the chart) and the outline of that disk. Moreover, the circles marked $\frac{1}{2}\odot + \frac{1}{2}\,♀$, and $\frac{1}{2}\odot - \frac{1}{2}\,♀$ indicate by their intersection with the various transit clouds, where external contact and internal contact respectively take place; for, manifestly, when *Venus*' centre, as seen from any station, is on the circle marked $\frac{1}{2}\odot + \frac{1}{2}\,♀$ (that is, is at a distance from the Sun's centre, equal to the sum of his radius and *Venus's*), *Venus* must be at the moment, and as seen from that station, in external contact, and similarly she must be in internal contact when her centre, as seen from any station, is on the circle marked $\frac{1}{2}\odot - \frac{1}{2}\,♀$.

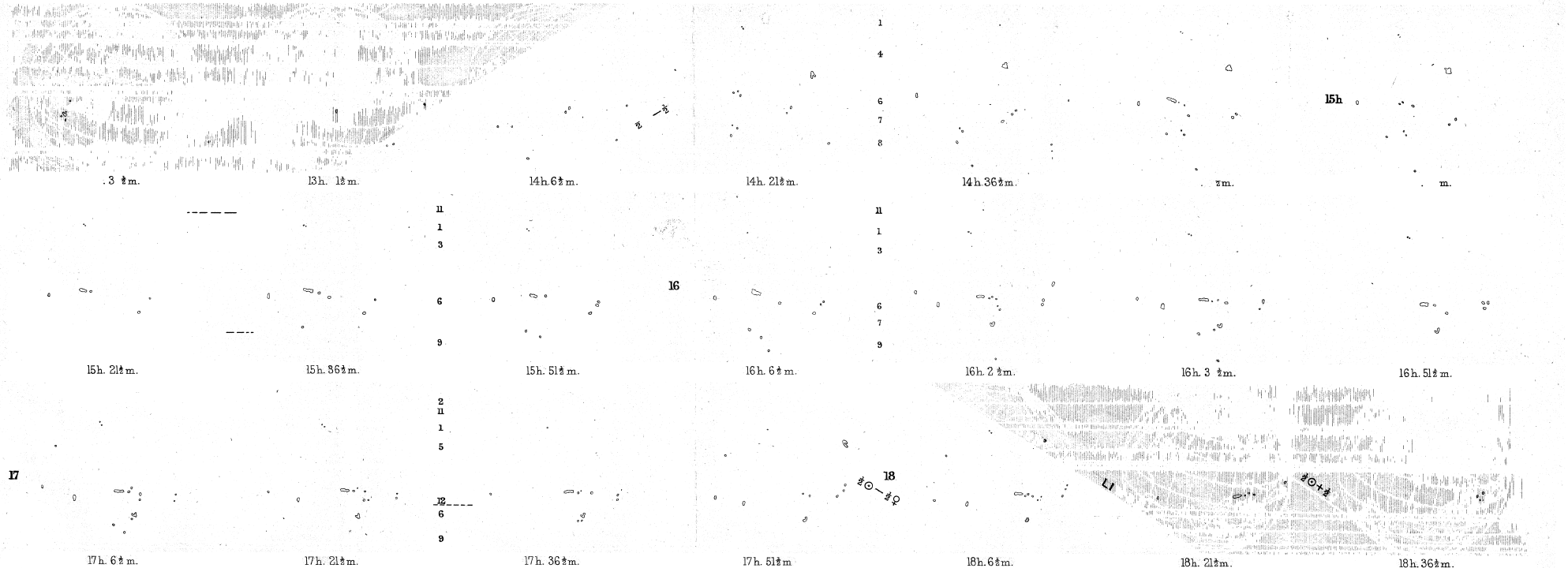
But fig. 3 serves to show more clearly how the illustrative chart is to be interpreted. It shows the northern half of the Sun's disk, and indicates the relative dimensions of the disk of *Venus* and the Sun, as well as the maximum parallactic displacement of *Venus*.

I apprehend that it has been demonstrated that (i) the Astronomer Royal's first and only discussion of the suitability of Halley's method in 1874 was based on insufficient evidence, was in itself incomplete, and led him to an erroneous opinion; (ii) that not only is the method more advantageously applicable in 1874 than in 1882, as regards time-difference, but that the objection of low solar altitude at a critical phase in 1882 has no existence in 1874; (iii) that the Astronomer Royal himself warmly advocated the equipment of Antarctic expeditions for viewing the transit of 1882 by Halley's method, notwithstanding the known difficulties; and (iv) that the best naval authorities on this

Downloaded from http://mnras.oxfordjournals.org/ at Florida Atlantic University on August 7, 2015

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

THE TRANSIT OF VENUS IN DECEMBER 1874. SHEWING THE PATH OF VENUS'S CENTRE ACROSS THE DISC OF THE SUN, AS SEEN FROM THE FOLLOWING TWELVE STATIONS:



R.A. Proctor, delt.

Malby & Sons, lith.

1873NRAS..38..279P

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System

1873MNRAS..33..291P

special subject concur in regarding Antarctic expeditions for viewing a transit early in December as altogether practicable.

The conclusion directly deducible from these results cannot be mistaken. England's duty is more than manifest ; it has been to all intents and purposes admitted by her astronomical and nautical official representatives. And I cannot but express my conviction that it will be little less than a national calamity, as assuredly it will be scientifically most regrettable if any considerations, either of convenience or of personal dignity on the one hand, or of false courtesy on the other, should lead to the loss of opportunities which will not be again available for many years to come.

Note on the direct Determination of the Parallactic Displacement of Venus during her Transit. By Richard A. Proctor, B.A. Cambridge.

Very early during my examination of the subject of the approaching transits, I was led to adopt and state the opinion that the parallactic displacement of *Venus*, and thence the Sun's parallax, might, in the present state of instrumental astronomy, be determined at least as accurately by direct measurement of *Venus's* position at successive epochs of her transit as by either Delisle's or Halley's method. It appears impossible to eliminate the error resulting from the clinging of *Venus* to the Sun's limb, after ingress and before egress ; and although several contrivances have been suggested for reducing this error, it is doubtful whether any of them will prove successful. It remains to be shown, moreover, whether photography can be successfully applied to determine the parallactic displacement of *Venus*.

I find that the German astronomers have for some time recognised the advantages which would probably result from such processes of measurement as I have mentioned; and their selection of Tchefoo, where the whole transit will be observable, indicates in a marked manner their preference for the direct method, since Tchefoo is not an exceptionally advantageous station for observing the accelerated ingress, and still less for observing the retarded egress. It is also inferior to other northern stations for applying Halley's method ; and indeed German astronomers have definitely indicated their preference for the direct method.

The American astronomers have also adopted a favourable opinion as to the direct method.

It appears to me that if English astronomers are to base their methods of procedure on foreign opinions (a growing fashion which I myself am far from urging as desirable) attention might not disadvantageously be directed to the considerations resulting from the above-mentioned opinions of German and American

Downloaded from http://mnras.oxfordjournals.org/ at Florida Atlantic University on August 7, 2015

© Royal Astronomical Society • Provided by the NASA Astrophysics Data System